# STRUCTURAL AGGREGATES SIZE INFLUENCE ON THE MICROBIAL BIOMASS CONTENT UNDER DIFFERENT LAND USE

**Marina LUNGU**[1]

e-mail: marinalungu7@gmail.com

**Abstract**

The main purpose of this research was to establish the relationship between microbial biomass content and the soil structural aggregates size in the leached chernozem from Moldova. For research was chosen three experimental plots in three different lands management systems. From this point of view was studied leached chernozem under 60 year-old fallow in the forest strip from the field edge (forest strip), the long-term arable chernozem with crop rotation without green fertilizers (conventional agriculture) and the long-term arable chernozem covered for nine years with cover crops (grass mixture of Ryegrass and Lucerne). The studies have shown that the microbial biomass content in soil aggregates decrease in the sequence: 60 year-old fallow land → arable land under ryegrass → arable land. The largest amount of microorganisms in the soil under fallow leached chernozem is concentrated in soil particles with a smaller size – 0.5-0.25 mm and < 0.25 mm. As a result, resistance of natural soil matrix to natural and anthropogenic negative impacts is higher than in the soils from agricultural ecosystems. The microbial biomass in arable chernozem is lower by 2.9-3.0 times than in the fallow chernozem. The microorganisms' distribution in the arable chernozem has more or less uniform character. The soil structure destruction and the significant deterioration of microorganisms in arable chernozems aggregates lead to their natural stability decrease and to the degradation processes development. The use of ryegrass for the long-term arable chernozem quality restoration contributed to the microbes' content increase in the soil aggregates with 14.4-15.1% but these values do not achieve the level of the soil under fallow.

**Key words**: soil biomass, soil structure, chernozem, land use

Soil physical and chemical degradation, more soil compaction and organic matter loss and soil sustainable use is the main problems that we have to face in the present times to guarantee a good population food supply while maintaining a healthy living environment.

Unfortunately, in the last decades soil has been significantly degraded on arable lands resulting in soil compaction, crop yields decreasing and erosion processes on ever wider surfaces extending, not only in Moldova, but also worldwide. Also a very sensitive indicator used to determine changes in soil is microbial biomass content. Although microbial biomass represents less than 5% of the total organic matter in soils, it plays an essential role in soil life contributing to substances transformation, pesticides degradation, and soil aggregation.

Previous research has established that soils framing is resulting in its biota degradation - a phenomenon found in close correlation with soil dehumification and destructuration processes (Senicovscaia, 2012). Conventional tillage system leads to structural aggregates destruction, and therefore of microorganisms habitat (Senicovscaia et al., 2010).

It is known the relationship between soil organic matter and soil structure as well as between organic matter and the spread of soil microorganisms. But the relationship between soil structure and microorganisms content in different sized structural particles was seldom studied worldwide and practically not studied in our country. So in this work we purpose to find an answer regarding the soil organic matter distribution in different soil structural particles sizes and what kind particles are preferred by microorganism as a habitat.

Microorganisms' interaction with organic matter and soil structure is complex and represents a heterogeneous phenomenon that contributes to soils quality and high productivity establishment. Soils used under perennial grasses, which form biogenic layer at the soil surface, compared with fallow and arable are ideal ecosystems for investigations of these interactions. In this context, the paper present an analysis of organic and microbial carbon distribution on different soil structural aggregates size in three different lands

[1] Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", Republic of Moldova, Chișinău

management systems from central part of Moldova, in order to put into evidence the changes that occur with the soil microorganisms along with the soil transforming under ploughing, farming and phytotechnical improving.

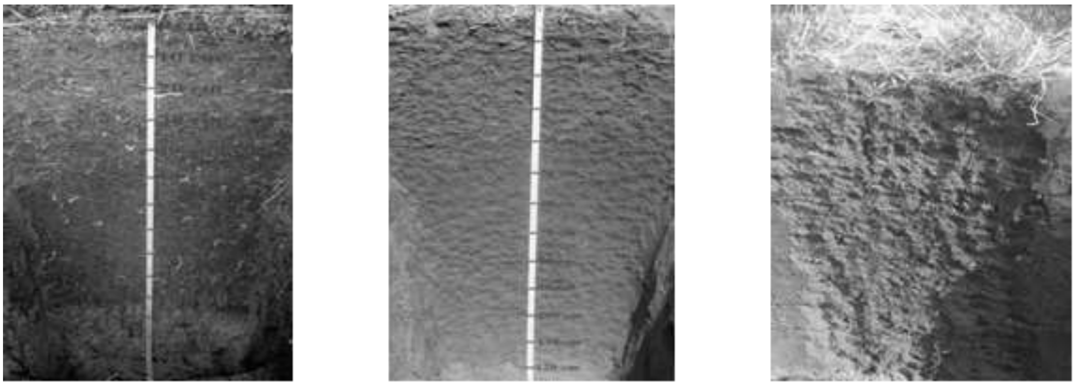

**Figure 1.** Studied soil profiles from Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field. Fallow leached chernozem - in the right, arable leached chernozem - in the middle and phyto improved leached chernozem - in the left

## MATERIAL AND METHOD

The research presented in this paper where carried out in the center of Republic of Moldova, in area named "Codrii", at Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental fields located in Ivancha village, Orhei district. The soil is the leached chernozem with humus content around 3.0% and pH ≈ 6.6 in the 0-25 cm layer. For research was chosen three experimental sites with different lands management systems as: leached chernozem under 60 year-old fallow in the forest strip from the field edge (forest strip), the long-term arable land with crop rotation without green fertilizers or cover crop (conventional agriculture) and nine years phyto improved arable land with grass mixture ryegrass+lucerne which are used each year as a green manure (grass strip) (Figure 2).

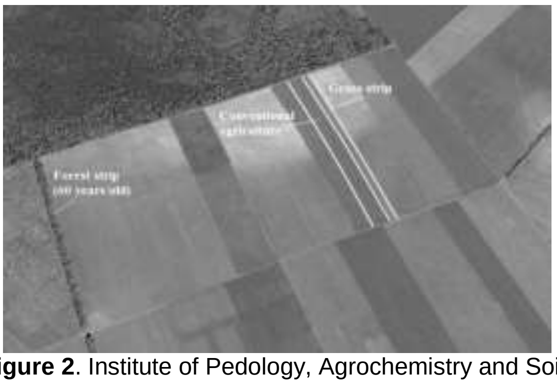

**Figure 2**. Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field used for current research**.**

Soil samples were taken out in five repetitions from every experimental strip from the depth 0-10 and 10-25 cm.

For soil structure parameters soil samples were collected from 0-10, 10-25 cm and also from 25-40 and 40-60 cm.

The data have been processed into the following indicators: soil structure, organic carbon content and microbial biomass carbon in soil structural aggregates.

For soil structural composition or aggregate size distribution assessment was used the standard classical dry-sieving method (Savinov, 1936). Where is taken 500 g of air-dried, undisturbed soil which is sieved through a cluster of sieves having 10, 5, 3, 2, 1, 0.5, and 0.25 square mm from which results eight aggregate size classes (>10, 10-5, 5-3, 3-2, 2-1, 1-0.5, 0.5-0.25 and <0.25 mm).

Soil organic matter (%) or organic C was analyzed by the dichromate oxidation method (Arinushkina, 1970). The carbon content was calculated using the coefficient of 1.724.

The microbial biomass carbon was measured by the rehydratation method based on the difference between carbon extracted with 0.5 M $K_2SO_4$ from dried soil at 65-700C within 24 h and fresh soil samples with Kc coefficient of 0.25 (Blagodatsky et al., 1987). $K_2SO_4$ - extractable organic carbon concentrations in the dried and fresh soil samples were measured simultaneously by dichromate oxidation. $K_2SO_4$-extractable carbon was determined at 590 nm with CΦ 103 spectrophotometer.

The obtained data have been statistically processed and interpreted. The microbial biomass index was evaluated statistically by the variance and correlation analysis.

## RESULTS AND DISCUSSIONS

Carried out researches show that leached chernozem under 60 year-old fallow from the forest strip is well structured in the entire profile. And the main part of the soil is joined in agronomic precious aggregates (Figure 3). But after 60 years the effect of soil plowing can still be recognized in the layer 12-25 cm.

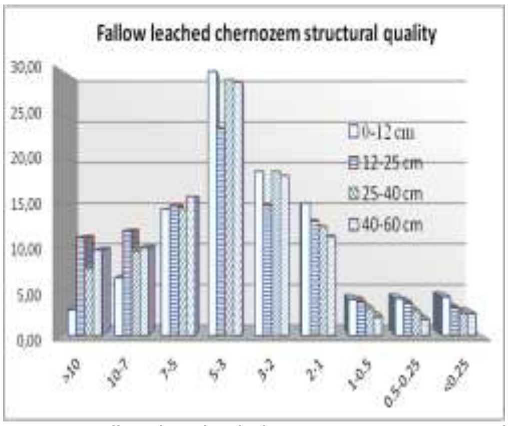


**Figure 3.** Fallow leached chernozem aggregate size distribution

Arable chernozem is bad-structured (Figure 4). Less suited for plant growth is exactly the layer of roots growth. First 0-10 cm from the surface are extremely dusty for the top layer. The underline layer 10 - 20 cm is so compacted, large aggregates greater than 10 cm are predominate here as a result of soil compaction in this layer.

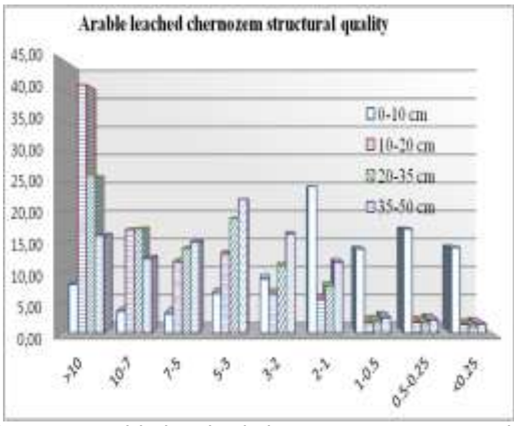


**Figure 4.** Arable leached chernozem aggregate size distribution

Cover crop roots and their green part introduced into the soil in phyto improved leached chernozem help to destroy the big soil particles in the layer 10-20 cm (Figure 5). So in this soil plants root system can obtain nutrients from thicker layer.

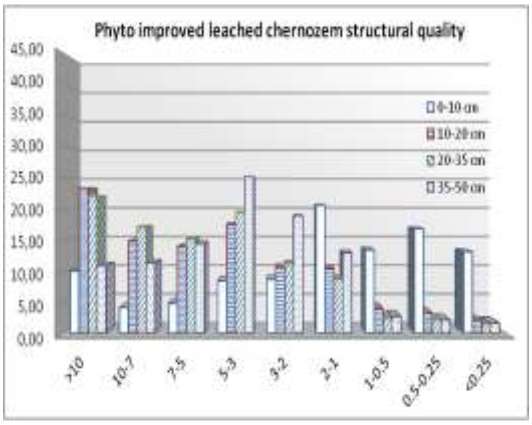


**Figure 5.** Phyto improved leached chernozem aggregate size distribution

The organic carbon values are higher in the fallow cernozem (3.0-3.5% in the top layer, 2.6-2.9% in the 10-20 cm layer). Arable and phyto improved soils carbon content is in the range of 1.7-2.1%.

In all three experimental sites organic carbon content have an almost uniform distribution in all soil aggregates regardless of the aggregates size.

But a size of soil particles plays an important role in the distribution of microorganisms in the aggregates fractions of leached chernozem under 60-years-old fallow. The largest concentrations of microbial biomass carbon were found in the layer of 0-12 cm.

The highest amounts of the microbial biomass in the layer of 0-12 cm of fallow leached chernozem in 0-12 cm are localized in fractions of 0.5-0.25 mm (16.9%) and < 0.25 mm (13.5%). The lowest amounts of the microbial biomass have been recorded in the fraction of > 10 mm (6.4%).

All remaining soil biomass was distributed approximately equally among soil particles with the size of 10-7, 7-5, 5-3, 3-2, 2-1 and 1-0.5 mm, which is 63.2% of the total amount. The link between microorganisms and soil fractions is strongly positive in 0-12 cm of fallow leached chernozem. Trend of the microbial biomass content in soil aggregates in the layer of 0-12 cm is described by the power function. Correlation coefficient constitutes R2 = 0.73.

The highest amounts of the microbial biomass in the fallow chernozem (layer of 12-25 cm) are localized in the fractions of < 0.25 mm (14.5 %), 0.5-0.25 mm (12.4 %) and > 10 mm (11.7 %). The lowest amounts of the microbial biomass have been recorded in the fraction of 5-3 mm (8.7 %). Fractions with the particles size of 10-7, 7-5, 3-2, 2-1 and 1-0.5 mm contained approximately the same number of microorganisms (881.6-977.1 µg C g-1 soil). Trends are described by the polynomial function with the high correlation coefficient (R2 = 0.89).

Soil matrix under arable chernozem contains significantly lower amounts of microorganisms in comparison with fallow chernozem in 0-12 cm layer and as well as in the layer of 12-25 cm (Figure 6). Enrichment of soil fractions with microbes was reduced by several times. It should be noted the decrease in the microorganisms abundance in the 10-20 cm layer. The trend of the microbial biomass and particles size in the arable chernozem is described by polynomial function of 6 degrees and reveals moderate and strong links (R2 = 0.63 and 0.75). The highest numbers of the microbes in the arable chernozem (0-10 cm layer) are localized in fractions of 7-5, 0.5-0.25 and <

0.25 mm (38.5%). The maximal amount of microorganisms in the 10-20 cm layer of arable chernozem were recorded in the fraction of 0.5-0.25 mm, their number reached 413.7 µg C g-1 soil. Statistically, all other factions of the chernozem under arable were not different from each other.

Microbial biomass in the leached chernozem under ryegrass in the 0-10 cm layer is localized mainly in fractions of 3-2, 2-1, 0.5-0.25 mm and > 10 mm fraction, in the 10-20 cm - in 10-7 mm and 0.5-0.25 mm fractions. The number of microbes in 10-20 cm layer is less by 10.2% in comparison with the 0-10 cm layer.

The link between the microorganisms and the size of fractions in the leached chernozem under ryegrass is positive and shows the strong correlation ($R2 = 0.72$ and 0.91). The trend is described by polynomial function of 6 degrees.

## CONCLUSIONS

Conventional agricultural management practices lead to leached cernozem agronomically valuable aggregates destroying (soil dusting) in 0-10 cm top layer and their hardening in big sized soil particles (soil compaction) in underlying 10-20 cm layer. It almost doesn't affect organic carbon content which is distributed evenly throughout all soil aggregates. But it affects microbes and soil organisms' habitat, so their content in soil and in its different size particles. The microbial biomass content in soil decrease in the sequence: 60 year-old fallow land → arable land under ryegrass → arable land. The number of microbes in the aggregates in the topsoil is always higher than in the lower.

The largest amount of microorganisms in the soil under fallow are concentrated in soil particles with a smaller size – 0.5-0.25 mm and < 0.25 mm. As a result, resistance of natural soil matrix to natural and anthropogenic negative impacts is higher than in the soils from agricultural ecosystems.

The microbial biomass in arable chernozem is lower by 2.9-3.0 times than in the fallow chernozem. The microorganisms' distribution on different sized structural aggregates in the arable chernozem has more or less uniform character. The soil structure destruction and the significant deterioration of microorganisms in arable chernozems aggregates lead to their natural stability decrease and to the degradation processes development.

The use of ryegrass for the long-term arable chernozem quality restoration contributed to the microbes content increase the in the soil with 14.4-15.1%. These values do not achieve the level of the soil under natural vegetation. In the layer 0-10 cm the higher concentration of microorganism's biomass is in the 3-2 mm structural aggregates unlike the arable chernozems.

## ACKNOWLEGMENTS

This work would not have been possible without the financial support of the Academy of Sciences of Modova, Ministry of Agriculture and Food Industry from Moldova for independent projects for young scientists No 15.819.05.09A. Also wish to thank the timely help given by coordinator of Soil Biology group from IPAPS "N. Dimo" Irina Senicovscaia in soil biology analyzing and its data interpretation."

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